

# *Subcontractor Report*

## **China PV Business and Applications Evaluation**

**September—October 1998**

Chris Sherring  
*Sherring Energy Associates  
Princeton, New Jersey*



# **NREL**

**National Renewable Energy Laboratory**

1617 Cole Boulevard  
Golden, Colorado 80401-3393

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Chris Sherring  
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NREL Technical Monitor: William Wallace

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## **Preface**

This report, which is the result of our visit to China during September-October 1998, evaluates the current status of photovoltaics (PV) business and applications in China. In the first section, an overview summarizes the findings; the remainder of this section describes the current status of the key aspects of the PV businesses, markets, and distribution channels. The next section provides data obtained from the businesses in the form of a completed questionnaire and company/organization profiles information organized in a table format. The following section includes a detailed itinerary of the trip. The contact information for all of the experts interviewed during the trip (Business Card Listing) is provided in the next section. Detailed company/organization profiles and summaries of visits made to China are provided in the subsequent section. These summaries were developed from the minutes of the various meetings that took place during the visits. The final section of the report offers a "photo album" consisting of snapshots of the Chinese businesses and/or their operations.

This composite document provides only some of the information gathered during this visit; more detailed, customized information, pertinent to specific sectors of the U.S. PV industry, is best conveyed directly to individual PV companies.



## Table of Contents

	<u>Page</u>
Preface .....	iii
List of Figures .....	vii
Findings .....	1
Introduction .....	2
Trip Itinerary .....	2
The PV Market in China .....	2
The Two Major Market Segments .....	2
Market Development .....	3
Financial Incentives .....	4
PV Product Distribution in China .....	4
Chinese Entrepreneurial Spirit .....	4
The PV Product Distribution Network .....	4
Product Quality and Affordability .....	9
PV Manufacturing in China .....	11
Overview of Existing Facilities/Capacity .....	11
Exploring Technology Options and Opportunities .....	14
Future Challenges .....	14
PV Businesses in China .....	15
New PV-Related Programs in China .....	16
GEF/World Bank and UNDP .....	16
The Dutch/Xinjiang Project .....	17
The Brightness Program .....	17
Conclusions .....	17
Company/Organization Profiles .....	20
Questionnaire .....	21
Profiles Tables .....	23
 Itinerary .....	 44
 Business Card Listing .....	 48
 Visit Report—Detailed Company/Organization Profiles .....	 66
Alpha Solar Energy Power Company, Ltd. ....	67
Beijing General Research Institute for Non-Ferrous Metals .....	67
Beijing New Building Materials Company, Ltd. ....	68
Beijing Solar Energy Research Center .....	68
Beinei Group Corporation—Diesel Engine Factory .....	68
Center for Renewable Energy Development .....	69
China Photovoltaic Technology Development Center .....	71
Dawa Solar Energy Company, Ltd. of Xining, Qinghai .....	73
Gansu GNERI Solar Electric Power Company, Ltd. ....	73
Gansu Provincial Electronic Industry Corporation .....	75
Gansu PV Company Ltd. ....	76

## Table of Contents (continued)

	<u>Page</u>
Gesang Solar Energy Ltd. ....	77
H.K. Company—Scheme Enterprises Holdings Ltd. ....	78
Hybrid Systems Site Visit to a Herding Area ....	79
Inner Mongolia Huade New Technology Company ....	80
Inner Mongolia Wind Power Generating Company ....	82
Inner Mongolian New Energy Office ....	83
Institute of Policy and Management, Chinese Academy of Sciences ....	84
Jike Energy New Technology Development Company of Beijing ....	85
New Energy Development Company, Ltd. ....	85
New Energy Office Renewables Demonstration and Test Center ....	86
Ningbo Solar Electric Power Factory ....	87
Pinggu County 100 Counties Program ....	88
Qinghai Provincial New Energy Research Institute ....	91
Qinhuangdao Hua-Mei Photovoltaic Electronic Company, Ltd. ....	92
Shenzhen Nenglian Electronics Company, Ltd. ....	93
Shenzhen—YK Solar Energy Company, Ltd. ....	94
Sinosolar Industry Company, Ltd. ....	95
Solar Power Development Center for Xining, Qinghai ....	96
World Bank Project Discussions ....	97
Yunnan Normal University/Solar Energy Research Institute (SERI) ....	97
Yunnan Semiconductor Devices Factory ....	98
Zhongxing Electronics Instrument Factory ....	99
 Photo Album .....	 101

## List of Figures

	<u>Page</u>
Figure 1. Typical solar home system .....	3
Figure 2. Solar shop's product range .....	5
Figure 3. Typical solar shop .....	5
Figure 4. Remote hybrid-powered home—Inner Mongolia .....	6
Figure 5. Hybrid system wiring and electronics .....	7
Figure 6. Remote hybrid site—Inner Mongolia .....	7
Figure 7. No wire and no neighbors—Inner Mongolia .....	8
Figure 8. Collection tank under construction for biomass system .....	8
Figure 9. Inner Mongolia site visit team .....	9
Figure 10. Local circuit assembly .....	10
Figure 11. Scale production of CFLs .....	10
Figure 12. Typical crystal-puller facility .....	11
Figure 13. Automated cell processing .....	12
Figure 14. Amorphous silicon deposition chambers .....	12
Figure 15. Qinhuangdao concentrator array .....	13
Figure 16. Shenzhen roof-mounted array .....	14

# Findings

# Findings

## Introduction

During the course of our 40-day visit to China, we met with more than 100 specialists in the Chinese renewables industry including all of the indigenous photovoltaics (PV) manufacturers, most of the distributors/systems integrators, and the key institutions involved in developing PV technologies and business. We also received considerable assistance from the Center for Renewable Energy Development, as well as 10 or more capable interpreters. With the help of all these sources, we were able to confirm that there are many encouraging signs—as well as many critical challenges—for both the international and indigenous PV industries in the energy markets in China.

Although more than 70 million people in China are without access to grid electricity, many of the unelectrified regions benefit from considerable renewable resources, including good solar insolation. Current annual PV sales are still modest, however, and are estimated to be between 2.0 and 2.5 megawatts (MW). The total market, which was about 2 MW per annum in 1998, is expected to grow at a yearly rate of between 20% and 30%.

## Trip Itinerary

Our China trip began in Beijing in early September 1998; subsequent visits were then made to Qinghai and Gansu, two of the northwestern provinces where many of the PV system distributors/integrators are based. We then returned to Beijing for visits to local institutes and attended the jointly sponsored Ministry of Agriculture and U.S. Department of Energy (DOE) renewables workshop. The next visit was to Zhejiang Province, which borders the east coast, for meetings at the Solar PV center and one of the PV module plants. Moving south, we then visited Guangdong province and its Shenzhen Special Economic Zone (SEZ) (adjacent to Hong Kong), followed by a visit to Foshan further to the west. The southwestern province of Yunnan and its capital Kunming (where another major PV module manufacturer is located) was next on the list. After passing through Beijing briefly, the next stop was in Qinhuangdao, the location of two more PV manufacturers (only a few hours train ride to the northeast of Beijing). After pausing for the Chinese national holiday, we visited Beijing, Hong Kong, and Inner Mongolia. All subsequent meetings and visits occurred in and around the Beijing area before our return to the United States in mid-October.

## The PV Market in China

### *The Two Major Market Segments*

The PV market in China is divided into the following two segments: industrial systems for powering communications in remote communities, such as the microwave repeater stations, fiber-optic links, and a small number of village power systems that range from a few kilowatts (kW) to 50 kW; and solar home systems (SHSs), which can be as small as 4 W or as large as 500 W. The latter provide power to satellite receivers and to remote households. Larger systems can consist of PV/wind hybrid systems with battery storage.

The industrial market segment, which is largely dependent on a small number of government contracts, is serviced by a very small number of system integrators, some of whom also manage their own module manufacture and assembly operations. The SHS market, by contrast, is served by many and varied types of suppliers, including nearly all the crystal silicon module manufacturers and the vast majority of the medium- and small-system integrators/distributors. Nearly all sales in both segments are made without any credit; however, in the SHS segment, small amounts of credit are provided by some module suppliers to their customers, who are the system integrators/distributors.

Typically, indigenous PV modules in China sell for between \$5 and \$5.50 per watt, whereas small systems sell at approximately \$10 per watt. Imported modules command a slight selling price premium.

### ***Market Development***

The vast majority of PV sales are made to remote rural provinces and autonomous regions such as Tibet, Xinjiang, Qinghai, Gansu, and Inner Mongolia; however, the PV production plants are mostly located thousands of miles away from these key markets. Currently, 90% of the modules supplied to the market in China are of indigenous manufacture. In addition, China exports single-crystal ingots and wafers (~ 1 MW) and most of the local thin-film production (~ 500 kW).

The PV market in China is at the early stages of development and the vast majority of the end customers are unable to evaluate the performance of the systems that are on offer. The vast distances between average rural customers in northwest China hinders the development of customer knowledge. For the SHS market, **selling price** is the key driver; as a result, the trend in recent years has been for the systems offered to become smaller to reach lower desired selling prices. The smallest SHS currently on offer has a capacity of 4 watts and the vast majority of the systems sold are below 20 watts (see Figure 1). Given the unsophisticated nature of the majority of SHS customers, some of the retailers (solar shops) tend to price systems according to the physical size of the module rather than the measured peak wattage of the module. Bigger is assumed, by the end customer, to be more valuable; however, given the range of cell diameters and efficiencies (and, hence, module area efficiencies), the actual size of a module may bear little resemblance to the module's effectiveness in a system.



**Figure 1. Typical solar home system**

## ***Financial Incentives***

Unlike other regions of the world, there are as yet no country-wide financial incentives in China to promote the use of PV and other renewables. The individual provinces have various subsidy programs targeting specific renewables and poverty alleviation funds are also used to reduce the cost of renewable power for remote, unelectrified homes. Although most forms of subsidy (designed initially to encourage technology adoption) can, after time, "distort" the market, the situation in China, particularly as it relates to small SHSs, appears to be coming close to a free market. The establishment and continuity of numerous solar shops and the healthy level of cash sales reflect a very significant commercial opportunity, considering the tens of millions of Chinese who do not have and will never have grid electricity. There is the risk, however, that failure to ensure that the cash customers are sold reliable products and provided with essential services, will damage the embryonic commercial market.

If large-scale bilateral programs such as the Dutch/Xinjiang project introduce unrealistic subsidies on PV systems (rather than offset the nonrecurring infrastructure investment), there is a real chance that the natural market mechanisms operating throughout northwestern China—the major market—will be destroyed. Similarly, if multilateral programs in China focus on accelerating market growth without fixing current product reliability and service infrastructure problems, the enormous PV market potential (> 15 MW per annum) might be lost forever or significantly delayed.

## **PV Product Distribution in China**

### ***Chinese Entrepreneurial Spirit***

The entrepreneurial spirit in China that has been clearly evident amongst private-sector distributors is increasingly being given every encouragement in the state sector, even within the many research institutions that are having to sell product to survive. This seemingly boundless entrepreneurial spirit impacts PV distribution most noticeably in the efforts of many small distributors/integrators, which have emerged to offer PV packaged products to rural customers at affordable prices. Although these distributors might typically employ 20-30 people and develop a network of sales outlets, they also try to "manufacture" much of the balance of systems (BOS) for the SHS to improve short-term profit margins. Typically, the depth of technical understanding and the appreciation of the type of manufacturing regime essential for the production of reliable, cost-effective electronics for remote rural applications, is limited or nonexistent.

### ***The PV Product Distribution Network***

Although the many distributors/integrators, some of whose businesses are profiled later in this section, obviously have varying degrees of technical and manufacturing skills, they have all developed multi-path channels to the rural markets. Many of the distributors have their own products or sell them through one of the shops on the "solar street" in Xining, Qinghai (see Figures 2 and 3). These shops, of which there are at least nine (not all in the one street), essentially all sell the same products, albeit from different manufacturers or with different logos, at more or less the same price. There is very little product differentiation as yet in these early stages of market development. Some outlets will focus on a specific ethnic group, as in the case of the Tibetan distributor that offers a complete range of Tibetan products in its Xining shop ranging from solar PV to dried yak meat to Tibetan video disks; however, there is little apparently that differentiates the other product offerings from each other. Because all these shops are currently viable despite the similarity of product, the inherent market potential is clearly evident.

In addition to shops, each of the distributors has developed various agents and regional salespeople who either sell on commission, buy and sell the product, or are fully funded by the distributor to sell the product



**Figure 2. Solar shop's product range**



**Figure 3. Typical solar shop**

in a particular region. As for product maintenance and guarantees, most distributors say that their agents and sales outlets carry out repairs of product under warranty. Some distributors go as far as leaving 10% of the purchase price (above and beyond commission) with the agent to cover possible repairs within the guarantee period. In the event that the product does not require repair, the remainder of the funds are passed to the distributor. Some distributors provide product training for their various agents; however, others talk of requiring the remote rural customer to mail the product back. When asked how many customers in any given year have mailed the product back, the remarkable answer is often zero. This cannot be simply interpreted in terms of the reliability of the product supplied; rather, what must also be taken into account is the logistical challenge facing a rural herdsman (who is possibly 50 km from the nearest small town), who has to mail an SHS to a distributor/integrator several provinces distant.

Some provincial energy offices have developed a network of county-level rural energy service centers with trained staff who also are beginning to sell commercial renewables product; however, many of the typical maintenance challenges currently experienced with the rural systems, namely repair to the circuit boards, require that the product be returned to the manufacturer. The rural herdsman, who typically has modest PV systems knowledge, may be as far as 100 km from the rural service center; without either electricity or phone, he needs to determine that the product has to be conveyed to the original manufacturer. (See Figures 4 through 7. Figures 8 and 9 depict construction associated with the ongoing 100 Counties Program and the comprehensive team that visited the hybrid units in Inner Mongolia.)

Larger state-owned distributors/integrators have launched market awareness/conditioning programs for PV and other renewables that include radio and newspaper advertising, as well as the distribution of product samples. The industrial market segment, which includes telecommunications power units, microwave repeater stations, and some village and island power units, is primarily served by a few established, full-service system integrators such as Beijing Jike Energy New Technology Development Company, Ltd., as well as some provincial research institutes. Few of the PV manufacturers, however, have the experience and resources to address this market segment. More typically, they simply supply the PV modules under contract



**Figure 4. Remote hybrid-powered home—Inner Mongolia**



**Figure 5. Hybrid system wiring and electronics**



**Figure 6. Remote hybrid site—Inner Mongolia**



**Figure 7. No wires and no neighbors—Inner Mongolia**



**Figure 8. Collection tank under construction for biomass system**



**Figure 9. Inner Mongolia site visit team**

to the integrator, who designs the system, acquires or builds the necessary inverters and controllers, and eventually installs the system and provides the guarantee and after-sales service. Small teams from the system integrator may then travel to a remote location in say, Tibet, become acclimated to the altitude, and then remain in that region for an extended period of time to complete the installation. As with any contract style of business, the annual demand is inherently unpredictable. In addition, given the extent of national and provincial government dependence, it is unrealistic to think of significantly enhancing this market demand in the short term other than by the addition of bilateral or multilateral programs.

### ***Product Quality and Affordability***

The use of circuit designs that are found to work in the laboratory, coupled with the purchase of off-spec components, no quality control, and no real customer feedback, may improve short-term profitability but will certainly damage the market in the long run. The small distributors tend to assemble the charge regulators and the dc circuits for the compact fluorescent tubes (see Figure 10), possibly saving \$1–\$3 in comparison with reliably produced components available in China. At the same time, military-quality electronics manufacturers, which make reliable controllers and dc light circuits (possibly even in the same city as the distributor/integrator) (see Figure 11), have significant production capacity, which is underutilized and may have higher product selling prices developed to support state overheads.

Overall system quality (including the electronics in general), however, seems to be of a high standard; at present, the locally manufactured modules are not causing significant reliability problems. The system specifications do not stipulate that module designs must undergo stringent reliability testing.

The key challenge today, however, given the absence of any significant credit mechanisms and the low and possibly even declining level of income of some potential rural customers, is providing an affordable PV product. Although the distributors have moved over time to even lower power levels (< 6-W SHS), the



**Figure 10. Local circuit assembly**



**Figure 11. Scale production of CFLs**

transaction costs and any after-sales service costs remain essentially fixed; ultimately, the end customer will find the modest power insufficient. One innovative distributor has developed a “trade-up” approach: when the customer has outgrown the initial small system, they can trade it in against the purchase of the next larger system. This distribution concept addresses the fact that the customer will probably amass more money over time and wish that they had purchased a larger system. However, the total cost of reselling the used system (possibly at a discount) and the additional transaction costs of re-servicing the initial customer, plus any reliability implications of the sale of the used unit, must ultimately be covered by the rural customer's limited resources. If the PV system reliability and sales margins are both high and unit transaction costs for remote individual rural customers can be kept low relative to product costs, then this approach may prove viable.

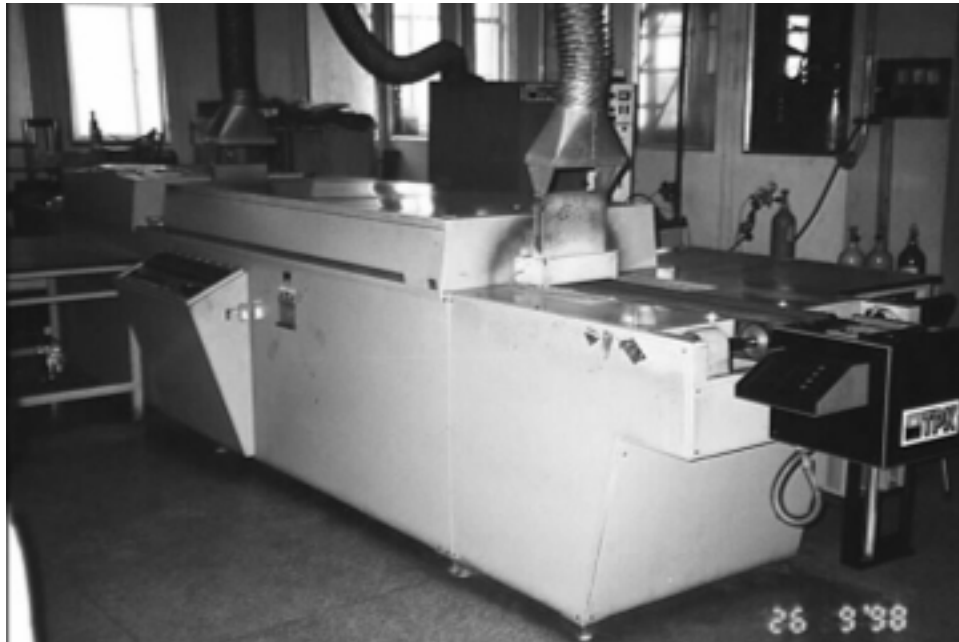
## **PV Manufacturing in China**

### ***Overview of Existing Facilities/Capacity***

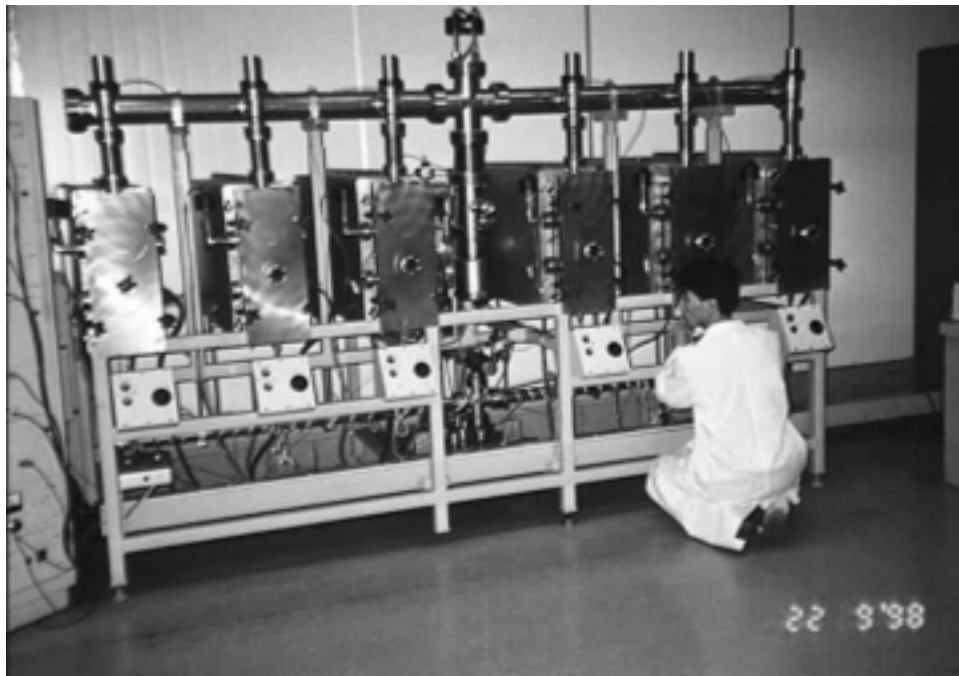
Despite the modest size of the current PV market in China, there are four comprehensive crystalline module factories, two module assembly plants, and two amorphous silicon (a-Si) thin-film module plants. Much of the major equipment for the photovoltaic plants originated in the United States and was imported in the 1980s. The crystalline-processing capacity is approximately 2.5 MW; the two a-Si (Chronar origin) plants are each 1 MW in capacity. Typical process equipment from several of the operational PV plants in China is depicted in Figures 12, 13, and 14. Single-crystal processing is significantly (at least five years) behind the cutting-edge processes used in the major international PV plants. There were no wire saws in



**Figure 12. Typical crystal-puller facility**



**Figure 13. Automated cell processing**

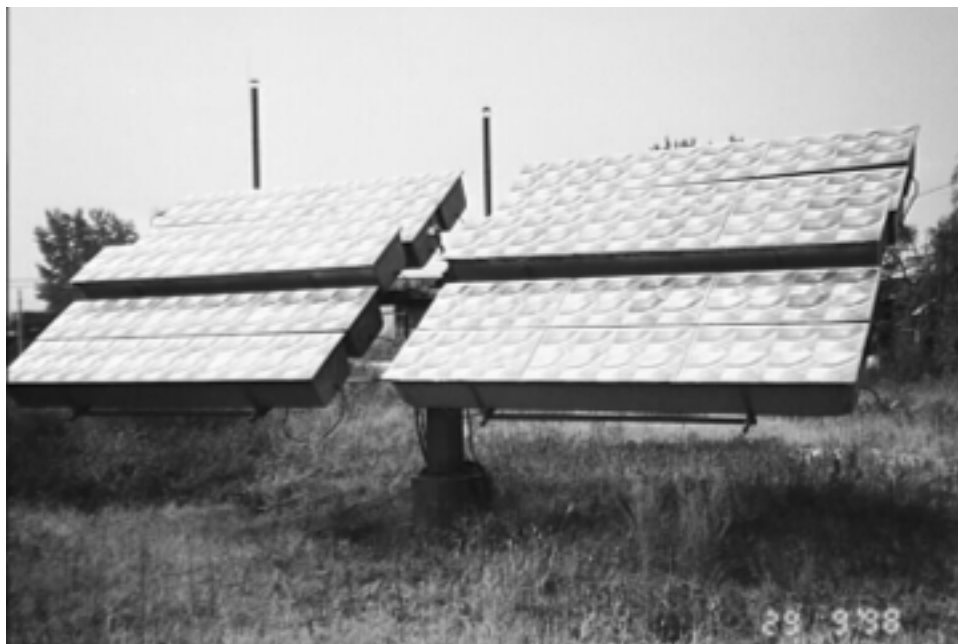


**Figure 14. Amorphous silicon deposition chambers**

evidence, and low-voltage small-diameter cells were used for much of the production at one plant. Also, as one might expect, given the cost of labor, the introduction of automation was somewhat limited. Many of the required small (low-wattage) PV modules were assembled mainly by hand. Most of the crystalline plants are operating on a one-shift basis, with elements of the processing such as crystal pulling and wafering run on a multi-shift basis. Laminators and solar testers with the familiar Spire logos were much in evidence, as were some new processing equipment and pullers of Chinese origin.

Neither of the two crystalline assembly plants were visited during the trip; however, the modules that are contract-assembled for Shenzhen Nenglian Electronic Company, Ltd., look and perform like modules purchased directly from Siemens. The amorphous silicon plant in Shenzhen, despite rumors to the contrary, was in operation, albeit at much reduced capacity and quality. The a-Si deposition equipment (see Figure 14) looks and runs well; however, the plant seems to lack not only essential spare parts to maintain the process in good working order, but also the qualified technical effort essential for achieving and maintaining even modest product-quality levels. The Harbin a-Si plant, which is of a somewhat older vintage than had originally been assumed, most likely operates in a similar manner.

An example of the first demonstration array resulting from the Alpha Solarco joint venture (JV) (established to transfer the x 400 concentrator technology) is shown in Figure 15. This technology will be installed at one village site in Tibet in 1999. An example of an indigenous crystalline array that has successfully survived a corrosive environment for five years (with some discoloration of the ethylene vinyl acetate [EVA]) is given in Figure 16.



**Figure 15. Qinhuangdao concentrator array**



**Figure 16. Shenzhen roof-mounted array**

### ***Exploring Technology Options and Opportunities***

Each of the operational crystalline silicon plants is in need of significant technical update if they are to ultimately compete with international vendors. The gap between Chinese manufacturers and the world's leading manufacturers, in terms of technological advancement and production volumes, is clearly widening; there is a risk that, as and when the Chinese PV market is scaled up, international suppliers could either dominate it from offshore or establish local plants without needing to collaborate with the existing, possibly outdated, Chinese plants. This scenario obviously assumes that the Chinese authorities would not block such efforts.

There is some evidence that polysilicon casting and wafer processing may be introduced in the next several years to avoid front-end bottlenecks and reduce, to a certain extent, cell costs. Meanwhile, there are many challenges and opportunities on the thin-film front. Indeed, after reviewing the current PV markets in China, we concluded that from a technoeconomic standpoint, a quality thin-film process would offer the best solution. Unfortunately, given the nature of the material produced today by the two existing thin-film plants in China, most if not all of their output is exported, and none of it was evident in any of the small SHSs. Indeed, the upcoming Global Environment Facility (GEF)/World Bank program for China has specifically excluded thin films, despite their obvious inherent performance advantages.

### ***Future Challenges***

Given the status of PV research and development in the Chinese institutes coupled with their own need to sell product to survive, and the sheer cost of updating the existing PV industry, the only realistic hope for a significant manufacturing technology advance would be through the establishment of joint ventures with the United States (or other recognized international leaders), or in some bilateral/multilateral initiative tailored to solve this growing problem.

Some of the principal challenges facing the Chinese PV manufacturing sector are as follows:

- Improve the quality of the product produced by one or both of the a-Si plants in China so that it can meet international performance standards.
- Begin to establish good thin-film performance with SHSs in northwest China using existing, quality thin-film product available from several U.S. manufacturers.
- Encourage the World Bank to reword the specifications to focus on established performance and reliability standards rather than a blanket exclusion of thin films.

Given the average income levels of many of the more than 70 million Chinese who have no electricity, as well as the current market trend towards low-wattage SHSs, solving the three challenges listed above should result in future market opportunities of > 5 MW per annum for any indigenous and overseas quality thin-film plants.

## **PV Businesses in China**

Each of the commercial PV businesses we visited during this trip were asked to respond to a questionnaire that had been supplied prior to the visits. The results of the survey—which have been transcribed into individual tables—are included in this section of the report. (Note: Whenever competitive commercial businesses are asked to respond to market share and total annual sales questions, their responses might be subject to some exaggeration; however, having in many instances toured the plants and evaluated their throughput, we are reasonably confident that the numbers are essentially accurate.)

Most of the businesses were modestly profitable but financially limited. All of the PV manufacturers were running significantly below capacity, despite the evident excess consumer demand for SHSs within China and significant export opportunities for reasonably priced, quality PV modules. Judging by the average margins and the level of excess capacity of the various plants, access to additional funds at reasonable interest rates would provide an opportunity to further increase profitability. In one particular instance, one of the PV plants (backed by a reliable letter of credit) had to turn down export business that was equal in value to all the shipments that it had made in China in that year.

Most of the technology companies expressed a desire to collaborate with U.S. firms, either in the PV or BOS area; however, they had little detailed knowledge of the capabilities of specific U.S. companies nor any regular contact with U.S. PV or BOS firms. Most if not all of the distributor/integrator companies were convinced that their homemade circuits were not only more cost effective, but at least as reliable as the professionally manufactured circuits supplied by the quality conscious, professionally managed Chinese factories.

Many of the distributors/integrators do not currently have the habit of issuing formal supply invoices to their customers. Nor do they pay taxes. In some instances, due to their size, they may not be required to formally register and pay taxes.

All of the small SHS distributors and most of the PV module manufacturers expressed hope that the upcoming GEF/World Bank program would help their businesses, either by providing a modest subsidy to the system supplier (\$1.50/watt per system) or by improving the viability of the distributors (thereby improving the health of the module suppliers' main customers). To date, there seems to be little understanding of the need for the existing distributors to:

- Opt for buying qualified system components at higher initial costs or significantly enhancing their own technical and production staff, in order to be able to make reliable systems.

- Install quality control procedures consistent with trying to produce quality systems.
- Establish customer service and repair infrastructures to fulfill the required product and service guarantees essentially required by the GEF program.
- Issue formal invoices to customers in order to ultimately collect the subsidy from the Ministry of Finance, and, in so doing, possibly be required to pay taxes that might offset any subsidy.

Not only do the small distributors need help to improve the quality of their BOS, they also need guidance and assistance in establishing comprehensive service infrastructures to enable a sustainable market to be developed in the midterm.

The industrial systems firms are subject to the unpredictable nature of the contract business, particularly at this early stage of PV market development in China when volumes are small. Their main technical needs are not in modules, but more in the BOS aspects of the latest, most efficient systems. Although there is a need for grid-interactive PV systems and sophisticated hybrid controllers, there is little evidence of suitable technology having been developed in China for either of these applications.

### **New PV-Related Programs in China**

Currently, there are several sizeable PV-specific or PV-related programs that are under development for China that can be expected to significantly change the size and character of the PV markets and business in China in the next few years. The key programs will be outlined here for completeness; however, comprehensive details on these programs should be available from the agencies listed.

#### ***GEF/World Bank and UNDP***

The World Bank/GEF Renewable Energy Project for China, which was scheduled to begin around June 1999, includes 190 MW of grid-connected wind farms and 10 MW of PV SHSs, together with technology assistance for local production of both PV and wind and technical assistance for commercial development. The total budget is more than \$390 million. The GEF/United Nations Development Programme (UNDP) Renewable Energy Project, which (like the World Bank Project) may begin before June 1999, involves capacity building for promoting commercialization, as well as technology demonstration. The budget for this program is \$26 million.

Currently, the target regions for the sale/installation of the PV systems are limited to the following six provinces/autonomous regions: Qinghai, Xinjiang, Gansu, Inner Mongolia, the west part of Sichuan, and Tibet. Given the likely concentration of a planned Dutch aid program for installing PV systems in the autonomous region of Xinjiang, there is a possibility that the World Bank project would favor the remaining five regions rather than “competing” with the extensive Dutch PV system program in Xinjiang.

As to eligibility for the GEF/World Bank project, the following users would be the focus: rural households, rural schools, rural hospitals, village head offices, and other village facilities. The PV systems can be 10 W<sub>p</sub> and above, together with wind and PV hybrids for households and 2-kW PV stations for non-household use. The focus is on the distributors; however, in order to help them to develop their business plans and to use qualified components in their systems, they may become eligible for a \$1.50/W<sub>p</sub> subsidy on systems sold in the target areas. Some fraction of the subsidy (say, 5%) may be retained till the end of the program to ensure that the suppliers' products perform well and that the distributors honor their guarantees.

Currently, distributors are on the list as being eligible to participate, although it is possible as the program progresses that this list might be reduced if firms cannot meet the required performance objectives. It is

envisaged that the 10 MW of PV will be installed over a period of five years. If the project creates additional business, this would double the annual demand for PV in China during the project.

The large-scale, grid-connected wind systems will be installed in four provinces on preselected sites. Power purchase agreements (PPAs) are already in place for the specific sites. The required turbines are to be ~ 300 kW per unit and the selling price of the generated electricity will be between 0.7 and 0.62 RMB (Renminbi, or “People’s Money”)/kilowatt-hour, depending on the site and its known wind resource. (Note—The exchange rate for the Chinese unit of currency is: ~8.3 RMB = \$1 U.S.)

### ***The Dutch/Xinjiang Project***

A letter of intent was signed for this project in March 1998. Various feasibility studies are under way involving the supply of 60,000 SHSs to be installed entirely in the province of Xinjiang. The project would entail the provision of Dutch funds to cover 60% of the cost of the hardware alone; at this time neither the service infrastructure nor the installation costs would be covered. These additional costs would need to be borne locally in China. The PV systems would mainly be between 25 and 50 W. Individual households might be expected to pay between 1,400 and 1,700 RMB per system at the 25-W scale. In addition, a smaller quantity of larger systems are apparently planned for Xinjiang. Shell was apparently selected to be the PV project company.

Nevertheless, there is considerable concern in the Chinese PV community that this project might eventually involve excessive subsidies at the point of sale, which would inevitably distort the PV market in the northwestern provinces. Those in the community fear that this would negatively impact their own modest margins.

Although this project may not add to the market for indigenous modules (because these would almost certainly come from Holland/Europe), it might be expected to have significant local resource implications for the modest-scale, quality system integrators/installers and the suppliers of reliable BOS.

### ***The Brightness Program***

In 1996, the State Development and Planning Commission launched the Brightness Program, with the overall objective of providing renewable power for lighting the rural unelectrified regions of China. The overarching target is to supply 20 million Chinese with small renewable systems by the year 2010. Although this program has adopted a considerable challenge, it has yet to be matched with adequate money to achieve these goals. However, ongoing programs within the individual provinces that adopt their regional goals, and any international collaboration programs that focus on renewables for rural areas, are being counted within the umbrella of this Brightness Program.

### **Conclusions**

- The status of PV manufacturing technology in China today is significantly (5 to 10 years) behind that of the West.
- The reliability of the modules from most of the manufacturers in China is not currently a pressing problem.
- Technology updates for the Chinese PV industry are not readily available from either provincial or national institutes, which are currently being encouraged to manufacture and sell products in competition with the very industries that need their help.

- There is an overwhelming desire to collaborate with the U.S. PV industry in order to update PV technology and develop its vast market potential; however, there is neither a clear understanding of the range of U.S. PV companies and their technologies, nor of their specific competitive strengths and weaknesses.
- In general, the “manufacture” of charge regulators, inverters, and dc light ballasts by 10–50-person distributor/integrator operations with limited experience is considered to be the least reliable aspect of the PV industry in China.
- The larger scale, professionally designed, quality controlled, manufactured product currently being produced in China is considered too expensive by distributors, which have opted to make their own. The real costs of any lack of reliability are probably borne by the end-use customers.
- The emphasis on low-cost systems assembled by distributors/integrators competing solely on the basis of price leads to the adoption of poor or unsuitable storage batteries, which, in turn, results in short battery life.
- The PV markets are currently dominated by small (~ 10-W), semiportable solar home systems, which are sold to widely dispersed rural customers, with little or no service infrastructure.
- Because of the limited resources of the majority of the distributors, the critical service infrastructure required to serve the remote markets has not been developed.
- The majority of existing and potential end users are ill equipped, at this stage, to make informed system choices.
- At this fragile stage of market development, there is a need for a buffer between remote, ill-informed rural customers and short-term, commercially motivated suppliers.
- There is a ready cash market today for many tens of thousands of SHSs per annum.
- Most of the current small SHSs that are sold to rural customers will probably fail within a short period (i.e., < 12 months).
- There is little quantitative data on the reliability of small systems in the remote markets.
- The very nature of the remote rural markets makes the absence of reliability data even more dangerous. No news is not necessarily good news.
- Some innovative credit mechanisms have been successfully applied to the sale of remote SHSs; however, there are many examples of ineffective credit programs.
- At the provincial level there is little knowledge of the critical evaluations undertaken and the experience gained in other parts of the world in adopting PV rather than grid extension as a reliable, appropriate, and more cost-effective way of providing electricity to remote regions. Making this data and experience available in the right form to a broad range of organizations concerned with the provision of services to remote communities, should accelerate the adoption of distributed PV electrification where appropriate.
- The modest module wattage of the majority of the current PV systems sold suggests that thin-film PV technology would be the most appropriate, reliable, and cost-effective choice for manufacturing solar panels.

- Poor experience with indigenous thin films has stalled the adoption of what is arguably the most appropriate technology.